NATIONAL TRANSPORTATION SAFETY BOARD
Office of Research and Engineering
Materials Laboratory Division
Washington, D.C. 20594

November 5, 2021

MATERIALS LABORATORY FACTUAL REPORT Report No. 21-076

A. ACCIDENT INFORMATION

Place	:	Horseshoe Bend, Idaho
Date	:	February 5, 2021
Vehicle	:	Hughes OH-6A, N6639R
NTSB No.	:	WPR21LA107
Investigator	:	Eric Gutierrez, ASI-WPR

B. COMPONENTS EXAMINED

Outlet fuel valve; P/N: 369A8466; S/N: Unknown; Manufacturer: E.B. Wiggins; Flexible fuel line.

C. DETAILS OF THE EXAMINATION

A fuel valve and flexible fuel line were sent to the NTSB Materials Laboratory for examination as shown in figures 1a and b, respectively. The two components were part of the aircraft's crashworthy fuel system. In the as-installed configuration, the valve was mounted on the exterior surface of a fuel cell by means of a mounting bracket (indicated in figure 1a) with the fuel inlet-side residing inside the cell. A separate fuel line (not examined or discussed) was connected to the valve inlet. The downstream portion of the valve was outside the fuel cell and consisted of a 90° elbow fitting followed by a length of rigid pipe. The downstream end of the pipe was threaded on the outer diameter surface for passing through and securing the pipe to a spacer/cover assembly with two nuts, one on either side of the assembly. The included fuel line was located downstream of the valve and upstream of the engine-driven fuel pump. The fuel line was visually examined but there were no notable features.

The valve reportedly was found to be leaking at the elbow fitting/pipe interface during post-accident testing in the field. The leak was reproduced in the lab by plugging one end of the valve and attaching the other end to a regulated air supply at 0.5 psi. Soapy water was applied to the elbow/pipe joint, and the soap began to foam near the 6:00 position, as defined and as shown in figure 2 (near the inner bend of the elbow fitting).

Before disassembling the valve, the elbow fitting/pipe joint was non-destructively examined using X-ray computed tomography (X-ray CT). A planar section through the CT scan is shown in figure 3. The scan revealed that the outlet of the elbow fitting contained uniform-diameter female threads into which was the pipe was threaded, with its uniform-

diameter male threads. An O-ring, compressed between smooth-wall sections of the fitting inner diameter and pipe outer diameter was used to seal the joint. The CT scan was examined for any notable features around the O-ring seal, such as a dislodged or broken ring, but none were found (It was observed however that the valve spring appeared to be partially dislodged).

Also before disassembling the valve, the visible smooth-barrel portion of the pipe was examined, as shown in figures 4a – 4d (see figure 2 for clock position identification). Circumferential scratch marks were observed around the barrel of the pipe. Viewed from the outlet end of the pipe, several scratches appeared to progress in the counterclockwise direction ending at a pile-up of material, such as the features indicated in figures 4b and 4d.

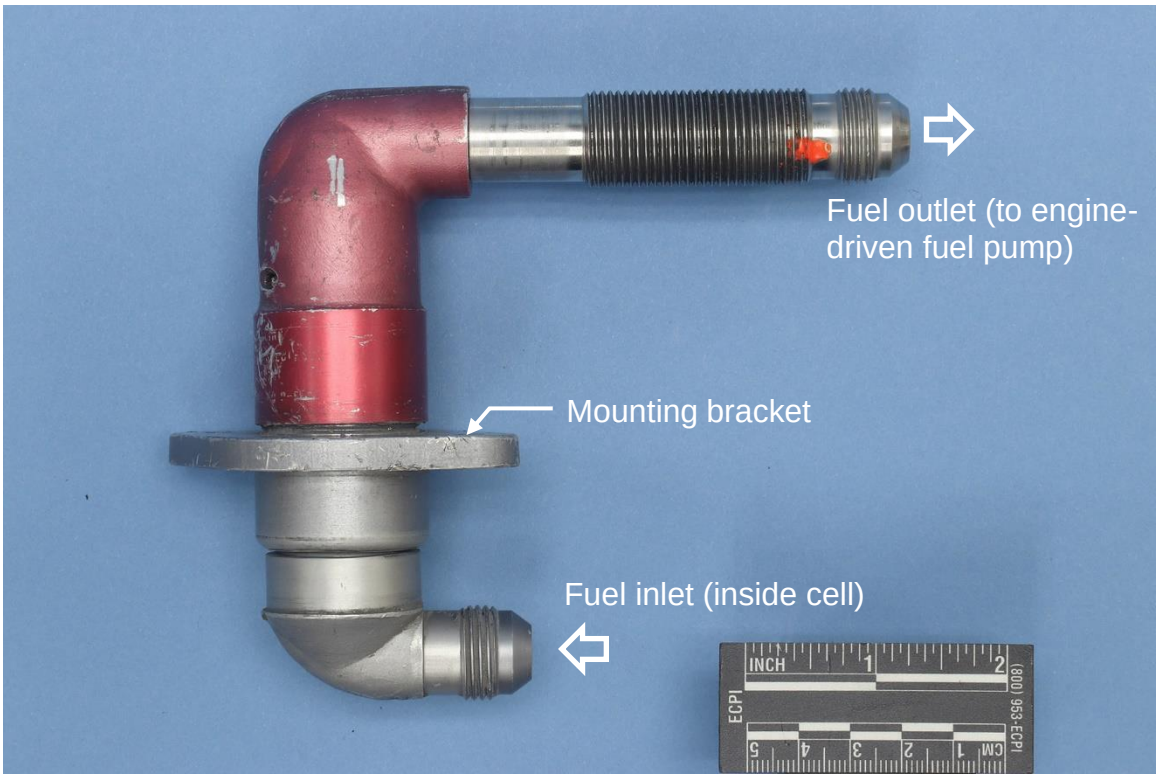
The pipe was then unthreaded from the elbow fitting. A disposable towel was wrapped around the threaded portion of the pipe and then a pair of pliers was used to grip the pipe/towel assembly. The pipe unthreaded instantly, requiring a minimal amount of applied torque. After the pipe was removed, the O-ring and inner diameter of the fitting were examined using a stereomicroscope. Images of the O-ring, as-seated in the fitting at 90° intervals, are shown in figures 5a – 5d and the threads at the opening to the fitting at the 9:00 and 3:00 positions are shown in figures 6a and 6b, respectively. Metal chips were observed on the O-ring surface as indicated in figures 5a – 5d. Examination of the fitting threads revealed that the first two threads at the 9:00 and 3:00 positions were damaged due to cross-threading, as indicated in figures 6a and 6b.

The O-ring was removed with a pick and is shown in figure 7a. The O-ring had a flat outer diameter and inner diameter surface, the latter shown in figure 7b. The region of the O-ring indicated in figure 5c, highlighting two metal chips near the 6:00 position, is shown in figure 7b. During removal of the O-ring, one of the chips fell off, revealing an impression left in the rubber, as indicated in the figure.

The remaining chip was lifted off the O-ring using a piece of carbon tape and was examined using a scanning electron microscope (SEM) equipped with an energy dispersive X-ray spectrometer (EDS) (an impression was also left in the rubber O-ring by this chip). An SEM image of the chip is shown in figure 8a and an EDS spectrum from the chip is shown in figure 8b. The chip was composed primarily of aluminum (Al) and silicon (Si). Comparison EDS spectra of the elbow fitting and the pipe were gathered and are shown in figures 9a and 9b, respectively. The spectrum from the elbow fitting consisted of Al and Si, similar to the chip, while the pipe spectrum consisted primarily of iron (Fe), chromium (Cr), nickel (Ni), and copper (Cu), consistent with a stainless steel.

Donald Kramer, Ph.D.
Sr. Materials Engineer

a)



b)

Figure 1: a) Image of the as-received fuel valve and b) image of the as-received flexible fuel line.

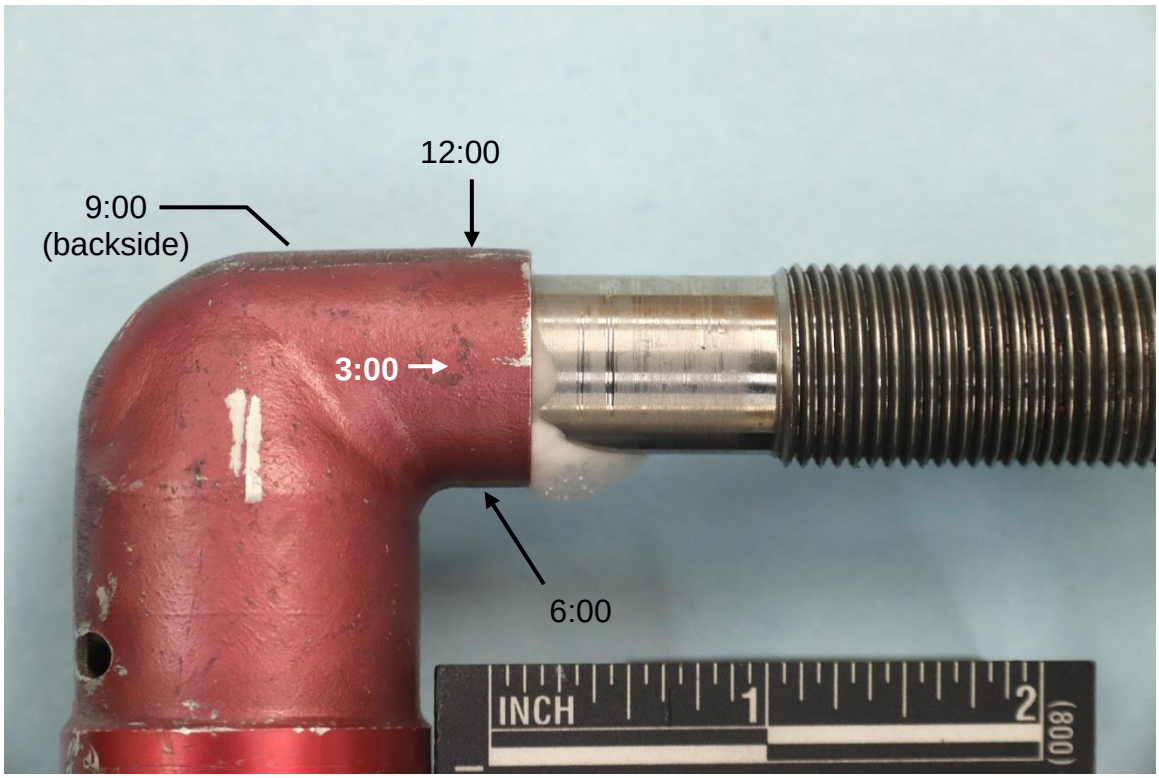


Figure 2: Image showing the outcome of a pressure test where soapy water was applied to the outside of a pipe where it was inserted into an elbow fitting. The soap foamed due to air leaking out of the fitting around the 6:00 position.

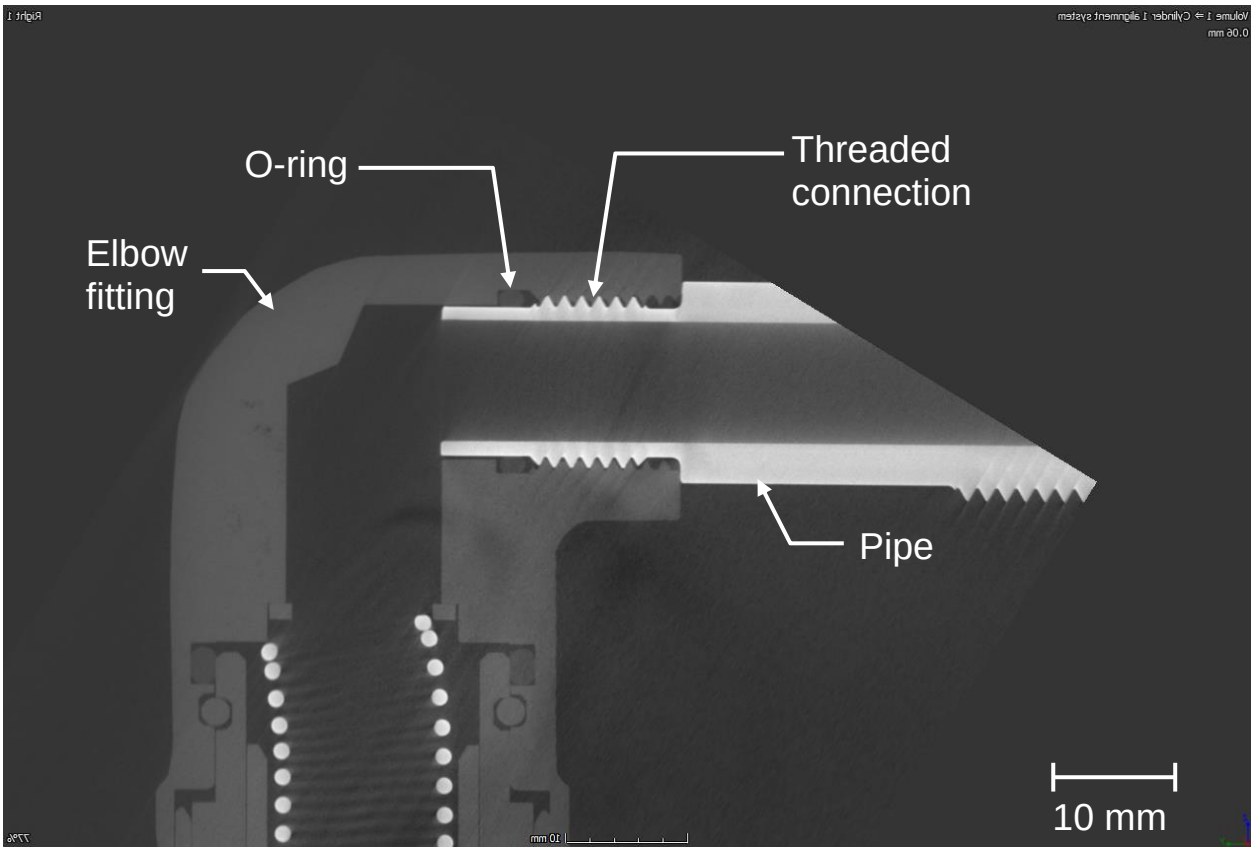
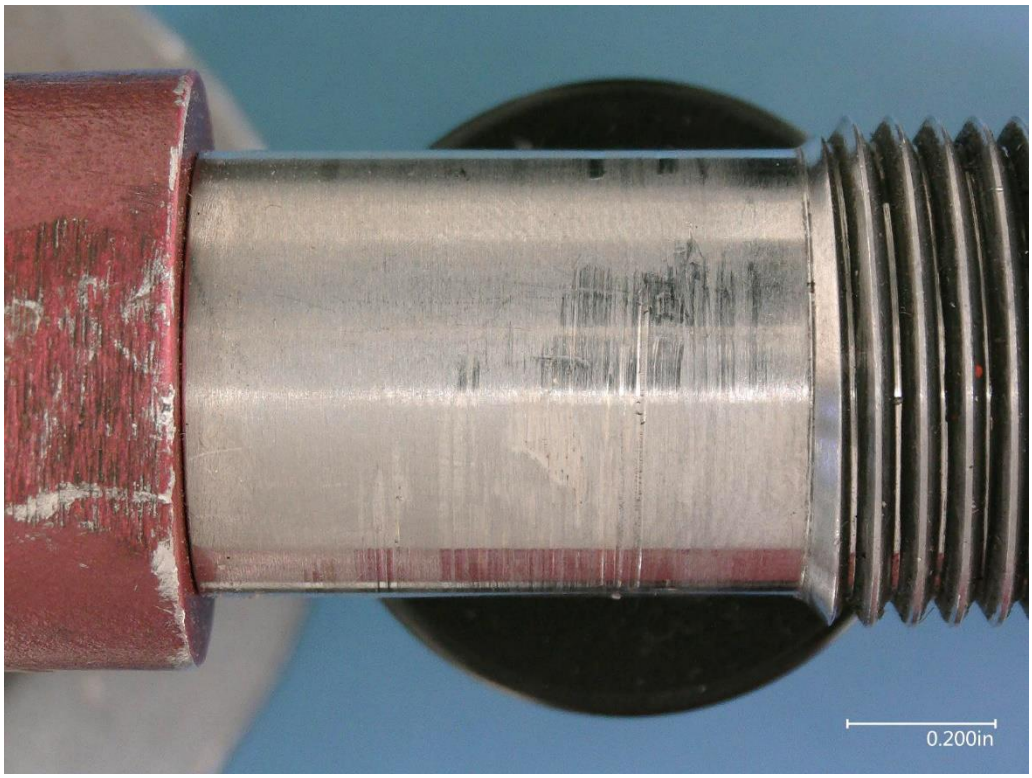


Figure 3: Planar section from an X-ray CT scan of the valve in the vicinity of the leak. The scan revealed that the pipe was a straight barrel with a threaded connection. An O-ring that sat between the outer diameter of the pipe and the inner diameter of the elbow fitting sealed the joint.

a)



b)

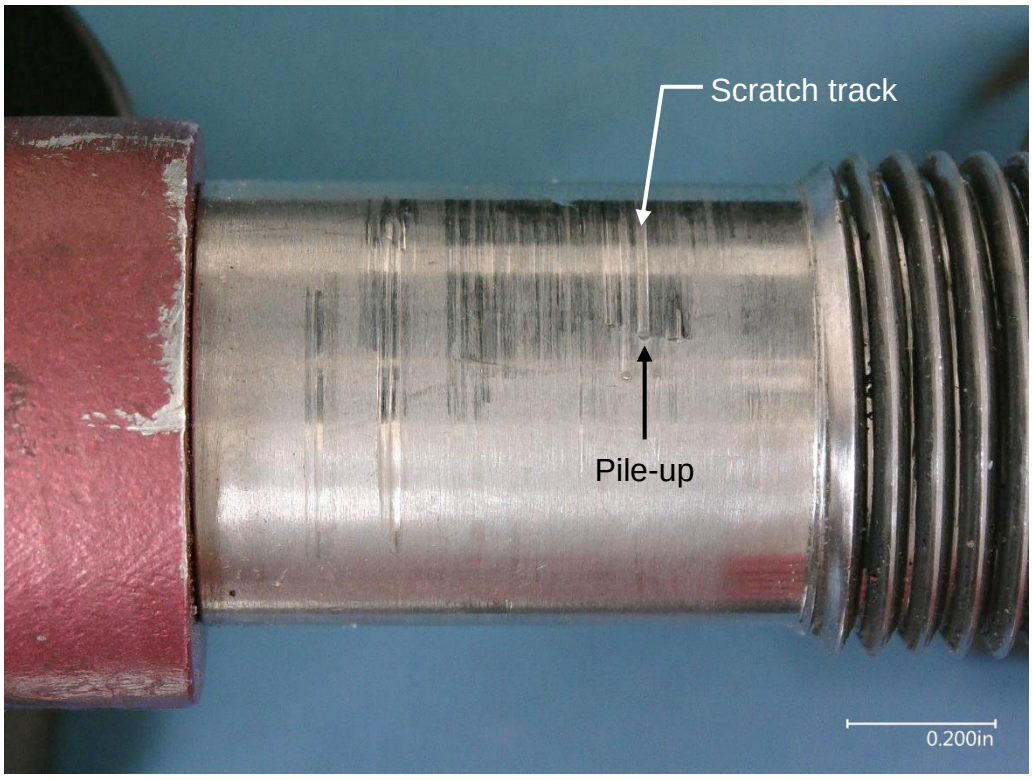
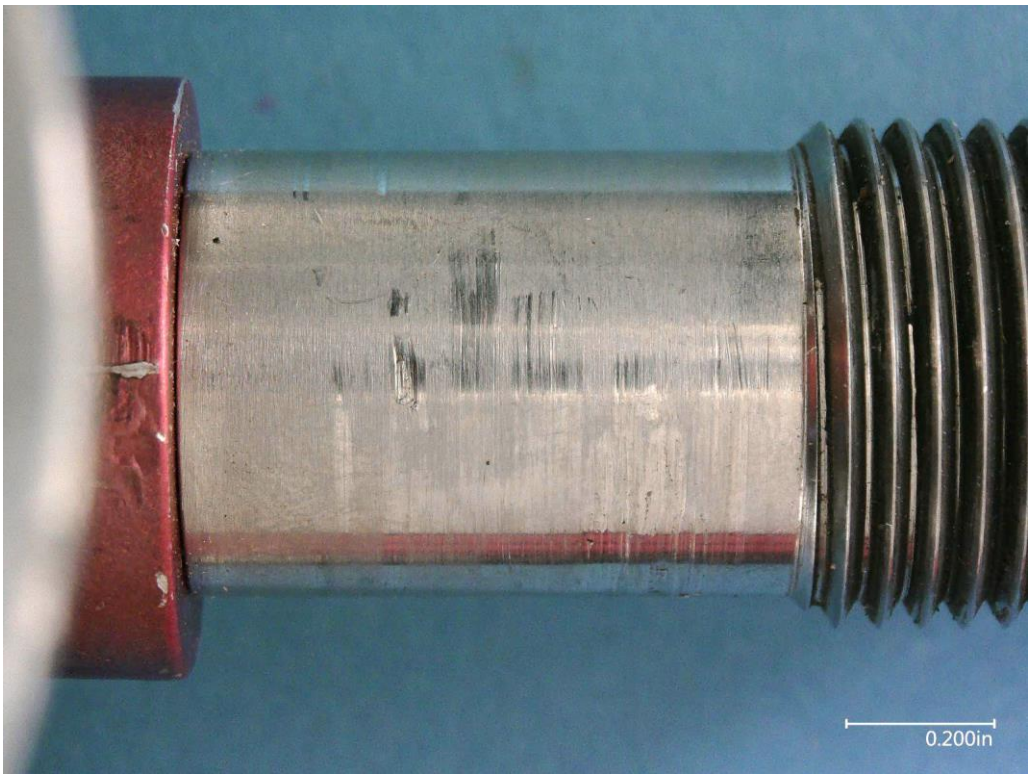


Figure 4: Optical microscope images showing circumferential scratch marks and pile-up material on the outer diameter surface of the pipe barrel: a) 12:00; b) 3:00;

c)



d)

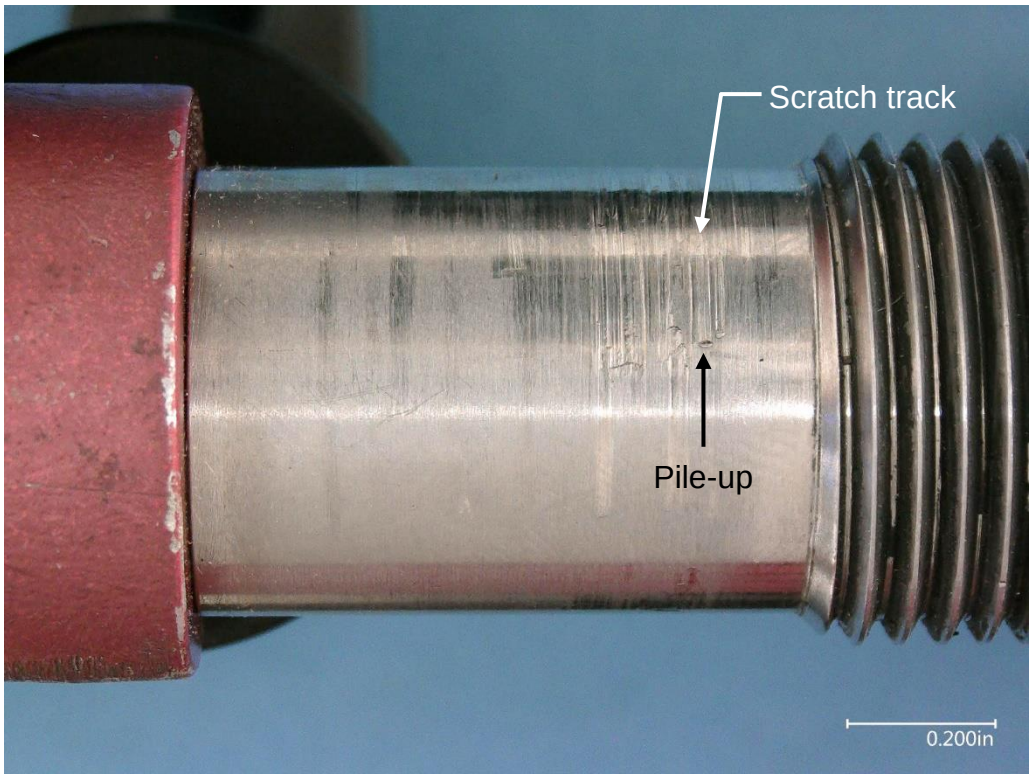
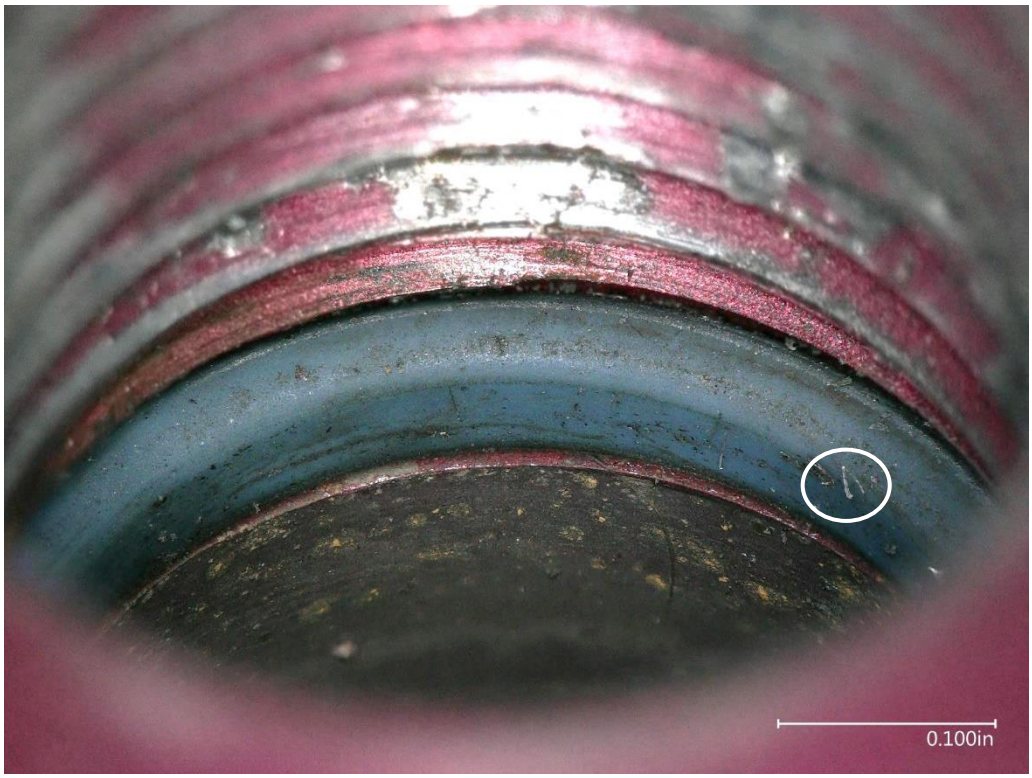


Figure 4 (cont.): c) 6:00; and d) 9:00.

a)



b)

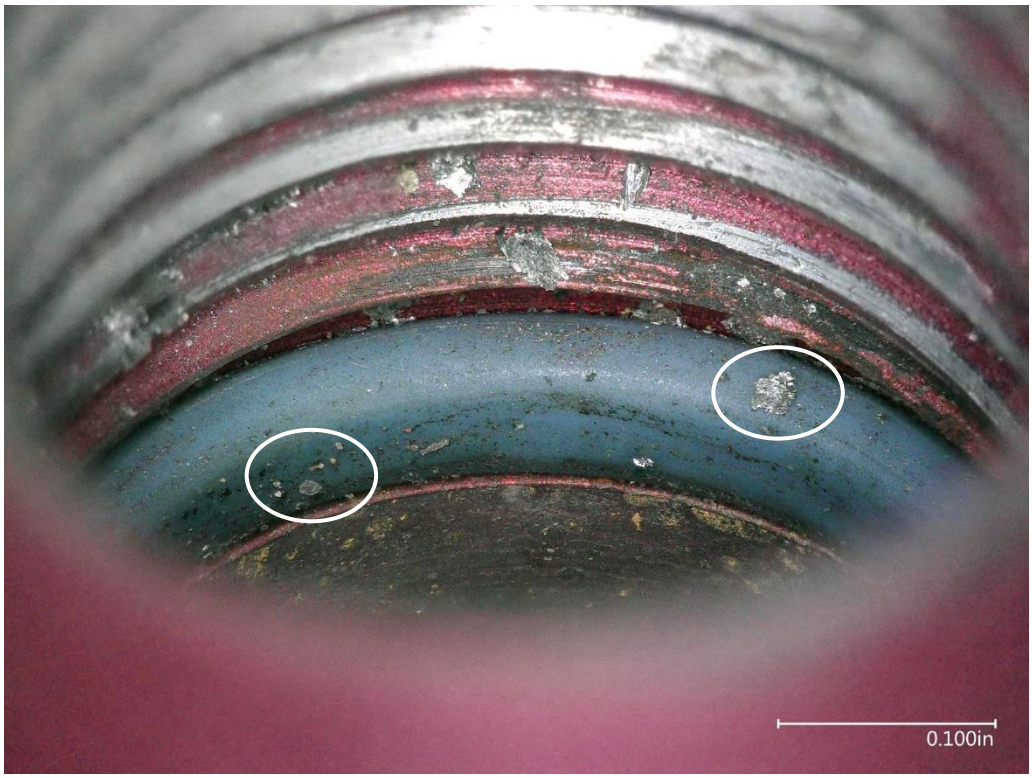
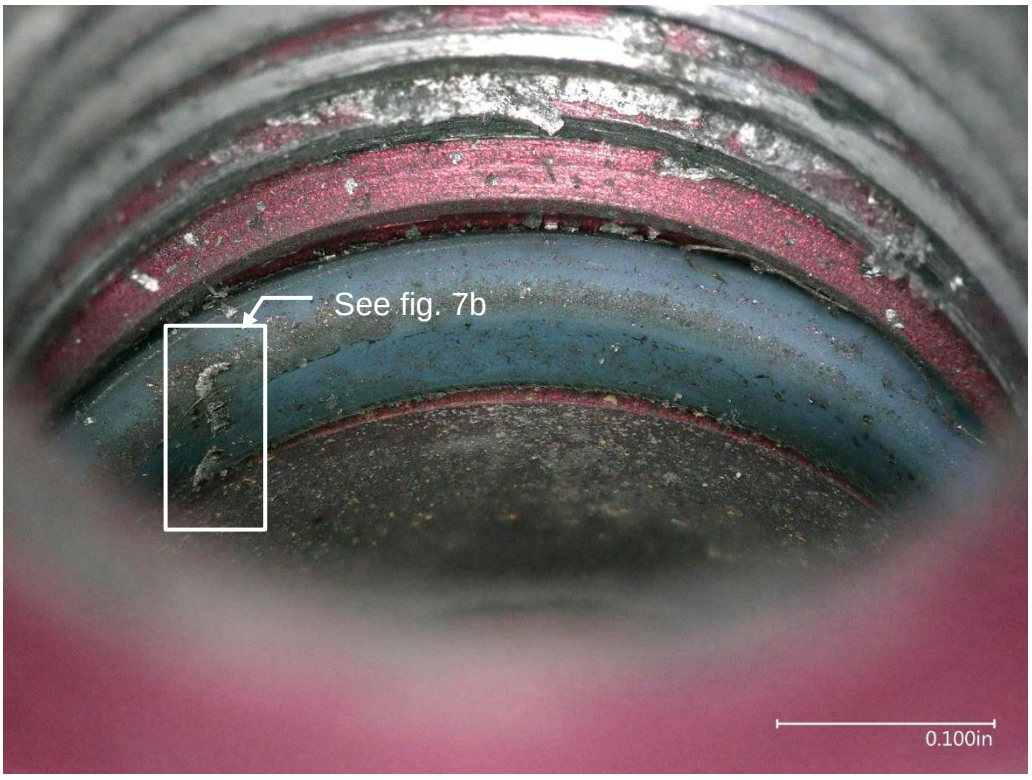


Figure 5: a) 12:00; b) 3:00

c)



d)

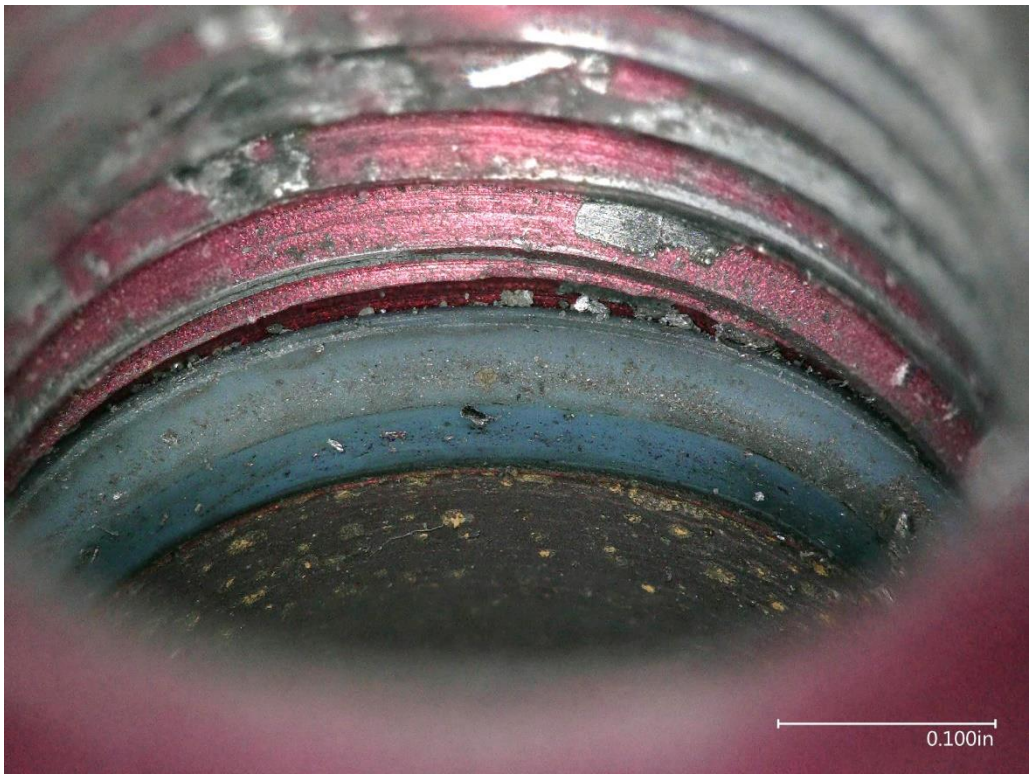
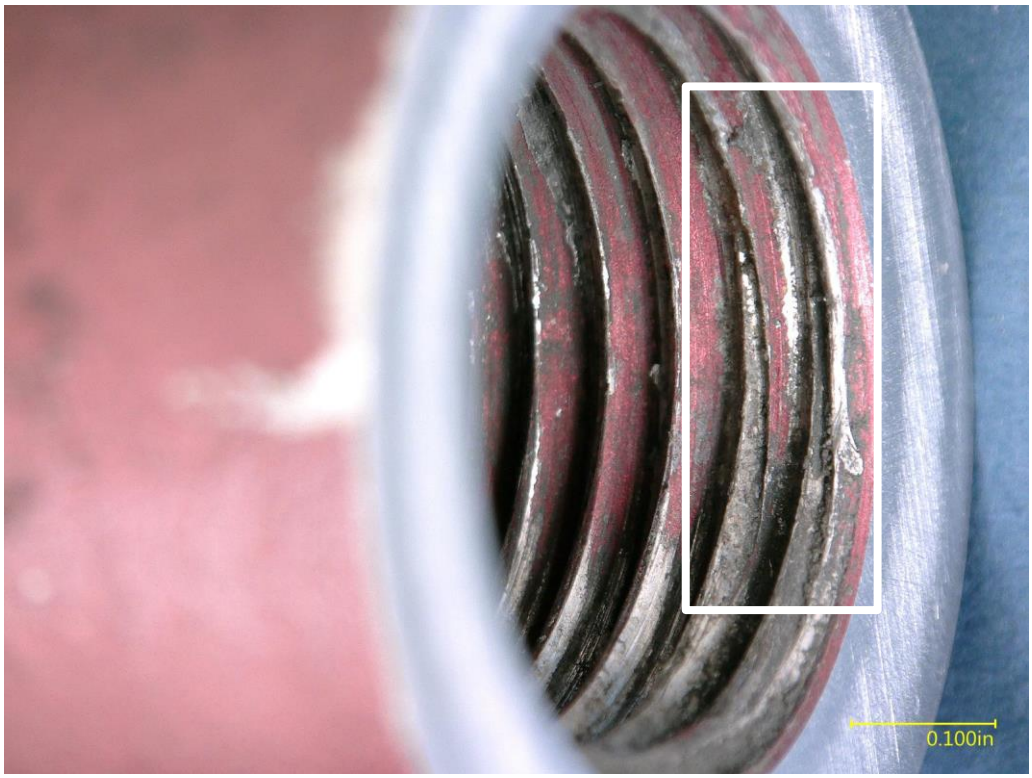


Figure 5 (cont.): c) 6:00; and d) 9:00

a)



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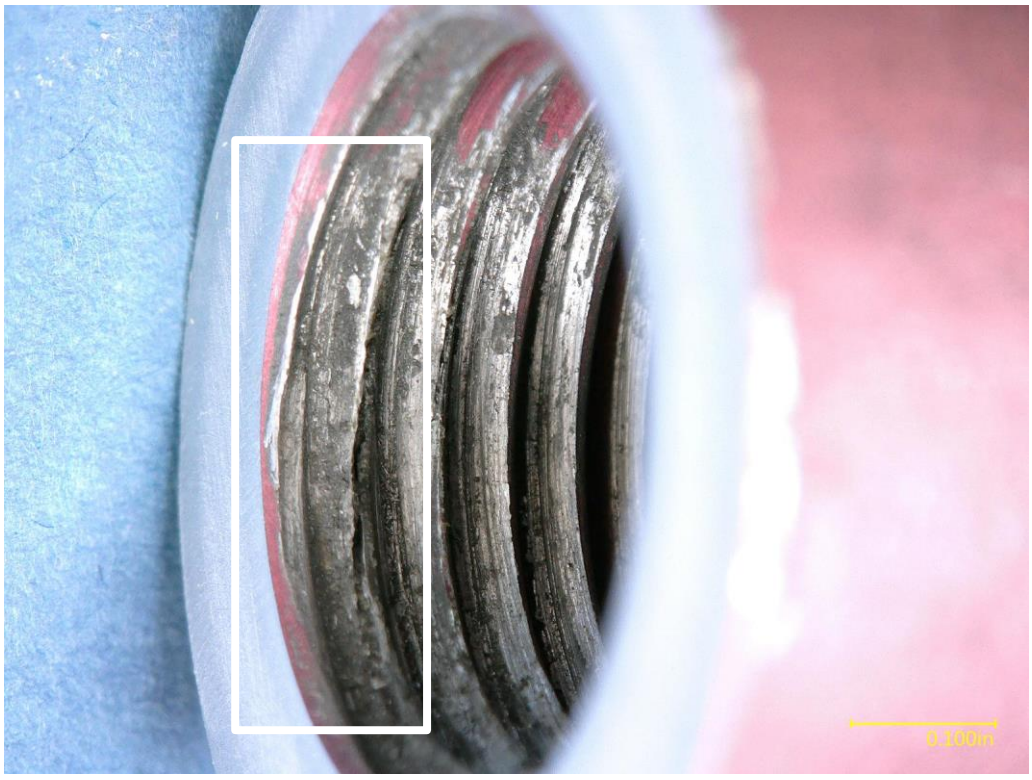
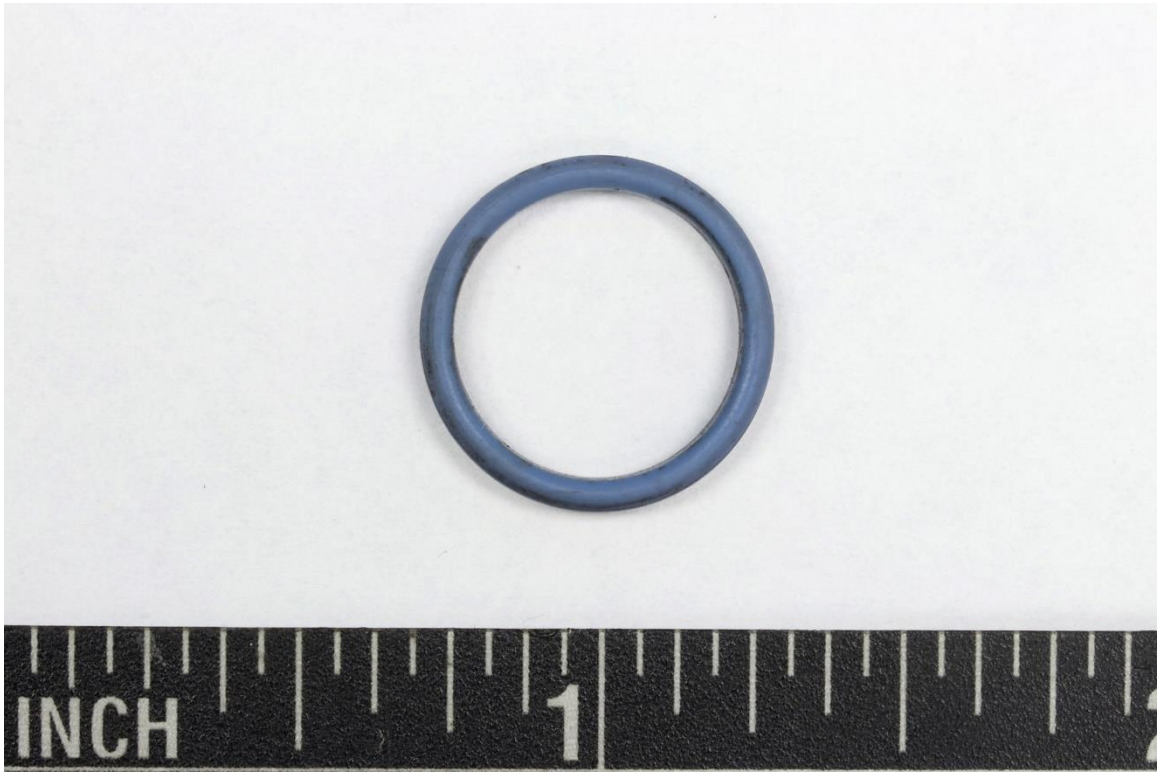


Figure 6: Optical microscope images showing cross-threading of the female threads on the elbow fitting: a) 9:00 and b) 3:00.

a)



b)

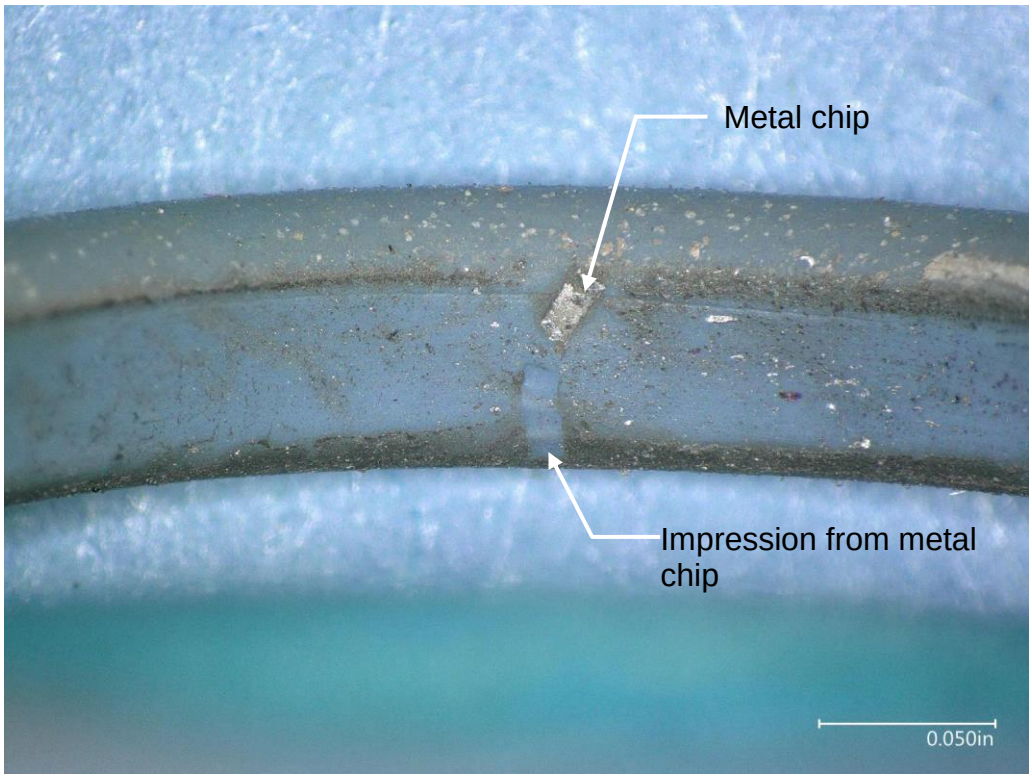
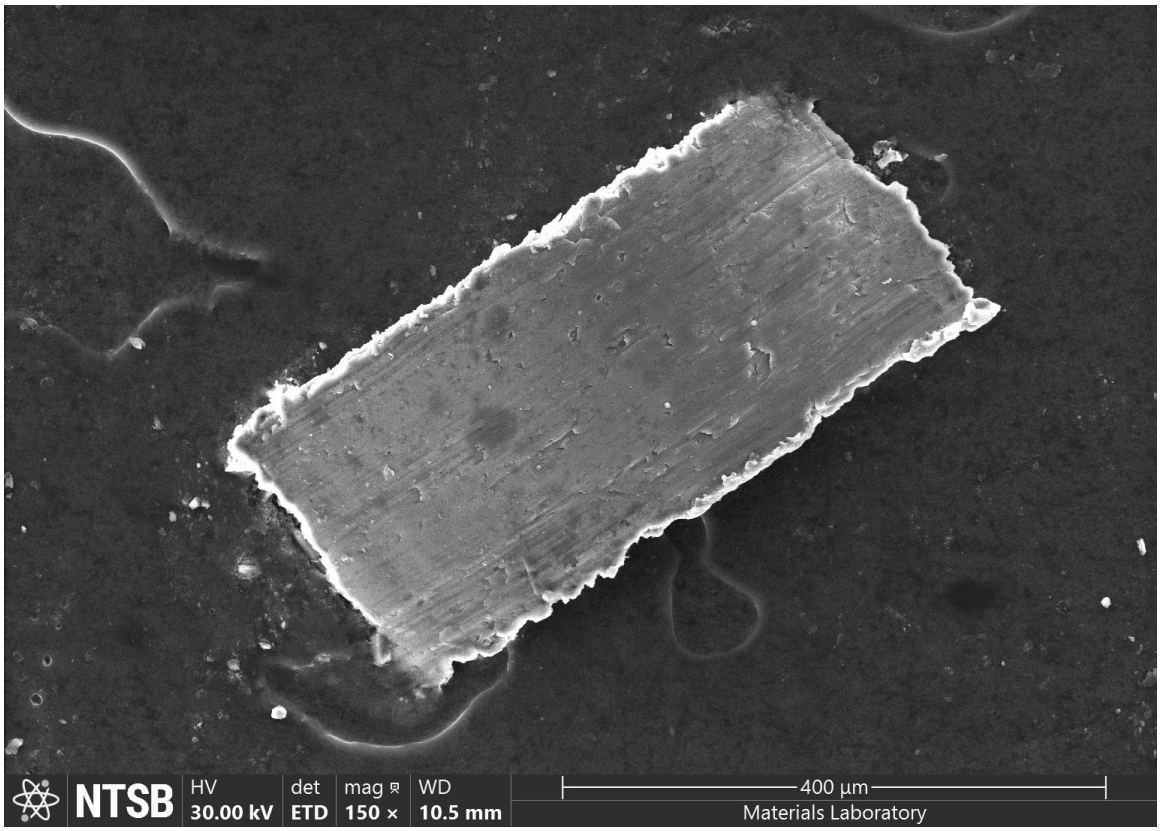


Figure 7: a) Overview image of the O-ring and b) higher magnification image of the O-ring showing metal chips that were embedded in its inner diameter surface.

a)



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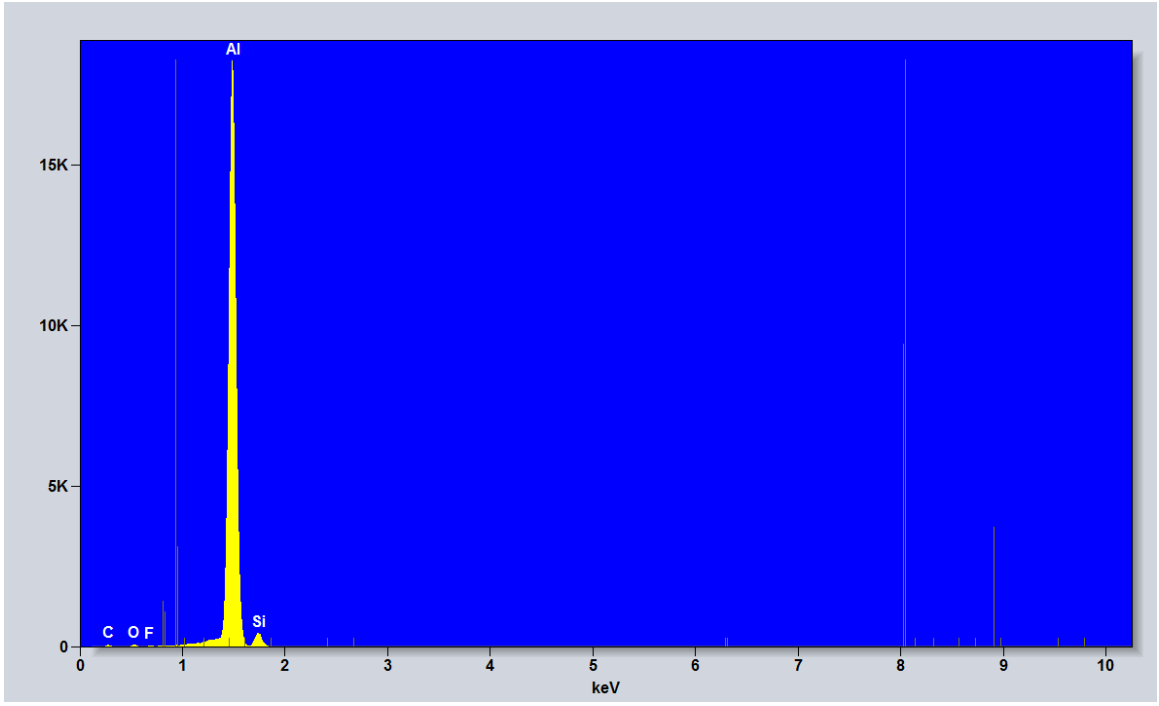
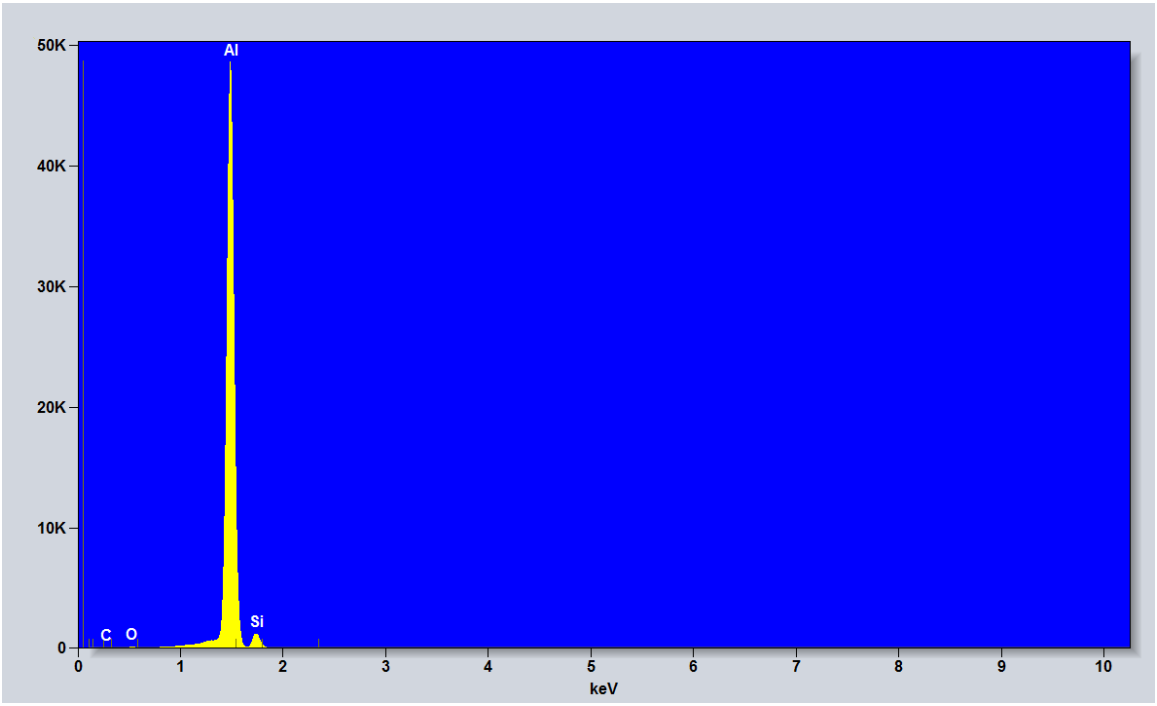


Figure 8: a) SEM image of the metal chip removed from the O-ring and b) EDS spectrum from the chip showing the presence of aluminum and silicon, consistent with an aluminum alloy.

a)



b)

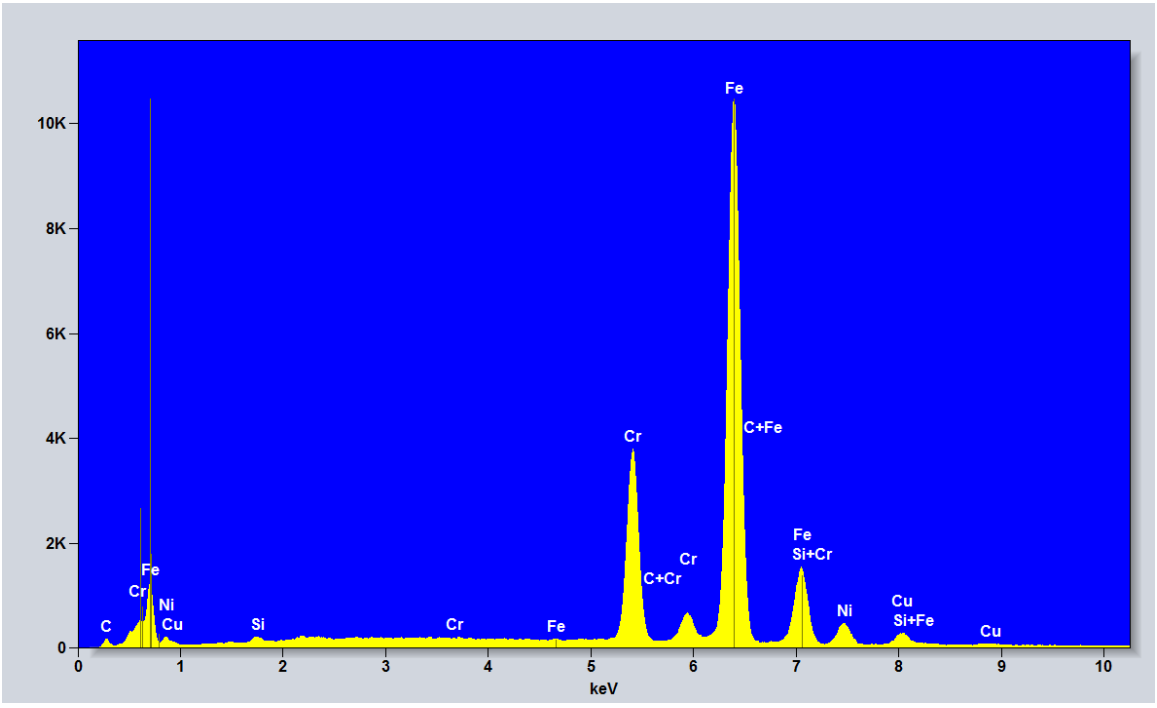


Figure 9: EDS comparison spectra from: a) the elbow fitting and b) the pipe.